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Ugly but tasty: a systematic review of possible human and animal health risks related to entomophagy

Marco Testa^{1,*}, Michela Stillo², Giulia Maffei³, Violetta Andriolo⁴, Paolo Gardois⁵, Carla Maria Zotti⁶

¹Department of Sciences of Public Health and Pediatrics, Turin, 10126 Italy, United States

Email: m.testa@unito.it

²Department of Sciences of Public Health and Pediatrics, Turin, Italy Email:

michela.stillo@unito.it

³Independent scientific communication expert, Milan, Italy Email: giuliamaffei@hotmail.it

⁴Department of Sciences of Public Health and Pediatrics, Turin, Italy Email:

violetta.andriolo@unito.it

⁵Department of Sciences of Public Health and Pediatrics, Turin, Italy Email:

paolo.gardois@unito.it

⁶Department of Sciences of Public Health and Pediatrics, Turin, Italy Email: carla.zotti@unito.it

*Corresponding Author Email: m.testa@unito.it

BACKGROUND

“All flying insects that walk on all fours are to be regarded as unclean by you. There are, however, some flying insects that walk on all fours that you may eat: those that have jointed legs for hopping on the ground. Of these you may eat any kind of locust, katydid, cricket or grasshopper. But all other flying insects that have four legs you are to regard as unclean” Leviticus 11:20-23.

The Old Testament is the old written document, which has been found so far, documenting the historical human habit of eating insects (Belluco, 2009). However, entomophagy (*éntomon*, “insect”, and *phagein*, “to eat”) has even deeper roots in human evolutionary history. Based on primates food habits, it is easy to infer that insects, and other invertebrates, were part of the diets of our earliest human ancestors (Tommaseo-Ponzetta and Paoletti, 2005; Fontaneto et al., 2011). For instance, isotope analysis of Australopithecine bones indicates a diet largely composed of animals such as insects foraging on graminaceae (Fontaneto et al., 2011; Klein, 2009).

In addition to this evidence, there are several other sources -- including a book collecting Leonardo Da Vinci’s cooking experiments -- indicating that insects have been part of the human diet and are still widespread in many parts of the world (Tommaseo-Ponzetta and Paoletti, 2005; Routh and Routh, 2005).

In addition to looking at them as nutritional resources, humans have historically taken advantage of insects as producers of honey, silk, and natural coloring agents, as well as for pollination or biological control. Nonetheless, insects have long produced a sense of disgust in people from most Western countries. Unsurprisingly, as we are increasingly interested in finding new sources of protein and reconsidering food resources that are ignored in the modern diet, insects have

attracted the interest of scientists, chefs and businessmen. As stated by the Food and Agricultural Organization (FAO) and other international organizations, mini-livestock (insect) food and feed might have considerable economic, environmental and nutritional advantages.

From a nutritional point of view, problems related to high levels of meat consumption have increased scientific interest in analyzing new sources of protein, and insects have been considered candidates for substituting meat for several reasons (Collavo et al., 2005; Payne et al., 2016).

It is difficult to generalize across the 2,000 insect species being consumed worldwide; however, compared to beef, pork and chicken, insect protein content is, on average, similar.

Insect essential amino acid scores range from 46 to 96%, although the majority of insects have limited levels of either tryptophan or lysine. In addition to protein, insects seem to contain more polyunsaturated fatty acids (although content varies significantly depending on the species and their diet) and higher levels of minerals, such as iron and zinc, and of vitamins B₁, B₂, and B₃ compared to other livestock animals that are of particular interest for women and children's diets, especially in developing countries (Belluco et al., 2015; van Huis et al., 2013).

Beside the nutritional aspects, preliminary environmental impact analyses estimated that livestock production consumes 30% of crops, 8% of freshwater resources, produces as much as 18% of greenhouse gas (GHG) emissions, and greatly contributes to global misallocation of reactive nitrogen (N) (Lundy and Parrella, 2015). Insects being farmed as mini-livestock result in lower GHG emissions and ammonia compared to the production of conventional livestock. An analysis conducted by Oonincx et al. in 2010 also suggests that less land area is required to farm mealworms compared to conventional livestock (Oonincx et al., 2010).

Preliminary economic impact analyses note the minimal technical or capital expenditures required for basic harvesting and rearing equipment. Insects can be easily breed, processed for food and feed and sold by all members of society including disadvantaged individuals, such as women and landless people in urban and rural areas (van Huis, 2013).

For the multiple potential advantages mentioned above, the European Commission is currently co-financing a research project to explore the feasibility of using insect protein for feed. The Commission is also considering how to develop policies that reflect the potential use of insects as novel foods and animal feed. Considering the lack of evidence related to this issue, the aim of our paper is to study the possible risks to human and animal health that are correlated with consumption of edible insects and to analyse the possible implementation of insect derivatives as in the pharmaceutical field.

METHODS

Eligibility criteria

The types of studies included are original experimental and observational articles; reviews were excluded. No limits for language or year of publication were applied during the search. The sample included all edible insects used as human or animal foods or drugs. Studies of any follow-up length were included. Settings included any country, state and community size. The interventions described in the articles included different type of risks.

Any type of control or comparison group not exposed to insects eating during the study period was considered. Studies without comparison groups were also included. Primary outcomes included risks of singular or prolonged consumption of edible insects. Secondary outcomes included pharmacological risks.

Search strategy

The following computerized databases were used for the basic search: PubMed/MEDLINE, Scopus, CAB Direct (the last searches were conducted on 16 November 2015).

To standardize and make the searches reproducible, the following search syntaxes were developed:

- 1) PubMed/MEDLINE: entomophagy [All Fields] OR “Insects”[Mesh] AND (“Nutritional status”[MeSH Terms] OR “Nutritive value”[Mesh] OR “Diet”[Mesh] OR “Dietary proteins”[Mesh] OR “Dietary Fats”[Mesh] OR edible [All Fields] OR eatable [All Fields]), using MeSH terms when supported.
- 2) Scopus: ALL (entomophagy OR insects AND (nutritional status OR nutritive value OR diet OR dietary protein* OR dietary fat* OR edible OR eatable)) AND SUBJAREA (mult OR medi OR nurs OR vete OR dent OR heal) AND (EXCLUDE (DOCTYPE, “ch”) OR EXCLUDE (DOCTYPE, “bk”) OR EXCLUDE (DOCTYPE, “cp”)).
- 3) CAB Direct: subject: (“insects as food”) OR (entomophagy) -- refine by journal article.

Inclusion and exclusion criteria

Inclusion criteria:

All articles clearly stating in title or abstract the intention to analyze the following topics were included:

- Risk of allergy: reported allergic reaction or laboratory confirmation of known allergens.
- Microbiological risk: reported microbiological contamination during any phase of production (collection, storage, transportation) or specific insect microbiological contamination.

- Chemical risk: reported presence of insect contamination with any known risky chemical substance or anti-nutrient factors.
- Malabsorption risk: reported risk of pathological nutrient malabsorption associated with the consumption of edible insects.
- Growth alteration risk: reported risk of pathological growth alteration associated with the consumption of edible insects.
- Hematic and qualitative meat alteration risk: reported risk of pathological hematic and qualitative meat alteration associated with the consumption of edible insects.
- Any other relevant risk related with edible insect consumption.
- Pharmacological effects: any reported pharmacological effects associated with the consumption of edible insects.

Case reports, qualitative studies or studies assessing clinical samples were included.

Exclusion criteria:

No limits for date of publication, authors, affiliation and language were applied.

All articles whose main objectives were not clearly stated in title or abstract were excluded.

Systematic and narrative reviews were excluded.

Study selection

The reviewers independently examined the titles, abstracts and key works of citations extracted from electronic databases for eligibility. For studies that appeared to meet the inclusion criteria, or when a definite decision could not be made based on the title or abstract alone, the full text articles were obtained to assess the inclusion criteria in detail. Studies were excluded if they did not meet one or more criteria. For any disagreements arising between the authors, that study was

discussed until a consensus was reached. The full text of all articles matching the inclusion criteria was reviewed. The reasons for exclusion were recorded.

Data collection process and data items

For each selected study, the data have been extracted using a standard form. Extracted data items included authors, year of publication, type of insect, human or animal consumer, type of consumption (singular or prolonged), primary outcomes (acute/chronic, allergic, chemical, microbiological, hematic, malabsorption and growth failure risks), and secondary outcomes such as pharmacological effects.

RESULTS

A total of 6,026 articles were retrieved from all databases; after deduplication of findings, 5,308 articles were targeted for analysis. Screening the titles and abstracts allowed the selection of 341 studies addressing the entomophagy-related risks and pharmacological properties of insects. A second screening, conducted in accordance with the study inclusion and exclusion criteria, allowed us to select 70 original articles that were eligible for the final analysis (flowchart).

We reviewed 70 studies, 26 of which studied insects as possible sources of human foods or drugs, 30 of which analyzed the use of insects in animal feed (23 poultry, 1 rats and 6 fish), and 14 considered edible insects as both food and feed.

The most studied insects were *Musca domestica* L, silkworm pupae and crickets in general, but the full list is available in Table 1.

Possible risks of prolonged consumption of insects were analyzed in 37 articles, while 23 studies did not specify the duration of consumption and 6 focused on possible risks of singular consumption of edible insects.

To provide more detailed findings, we decided to split the results into two main groups. The first takes into account all articles whose outcomes could be directly or indirectly linked to human health, including studies on rats and oil laboratory analysis. All insects analyzed in this group are commonly consumed by humans.

The second one includes all studies addressing edible insects as animal feed.

Humans

A total of 40 articles analyzed possible risks of health or drug effects caused by edible insect consumption by humans; 5 studies showed possible risks of allergy due to the presence of cross-reactive allergens in insects, suggesting that it is wise to advise individuals with known allergies to shellfish or mollusks to avoid eating edible insects. (Barre et al., 2014; Verhoeckx et al., 2014; Barennes et al., 2015; Broekman et al., 2015; Srinroch et al., 2015).

Microbiological contamination risk was analyzed in 4 studies, 3 of which suggested possible fungal or bacterial contamination due to poor sanitation and inadequate collection, drying, transportation, storage and marketing conditions (Klunder et al., 2012; Simpanya et al., 2000; Braide and Nwaoguikpe, 2010; Hernandez-Flores et al., 2015).

Possible chemical contamination, presence of anti-nutritional factors and oxidative potential of edible insects were analyzed in 9 articles, only 3 of which could exclude, given the current state of the art, a risk for human health (Braide and Nwaoguikpe, 2010; Adeduntan, 2005; Hyun et al., 2012; Memis et al., 2013; Koc et al., 2014; Musundire et al., 2014; Shantibala et al., 2014; Turkez et al., 2014; Omotoso, 2015).

Health risks related to the malabsorption of nutrients derived from edible insect consumption were studied in 16 articles; 10 studies excluded such a risk while the others stressed the need for

additional efforts to better understand the role of the specific anti-nutrients, such as tannin and phytate, contained in edible insects and how processing methods could affect the nutrient potential of edible insects (Adeduntan, 2005; Hyun et al., 2012; Musundire et al., 2014; Omotoso, 2015; Adebawale, 2005; Omotoso, 2006; Zhou and Han, 2006; Omotoso and Afolabi, 2007; Kinyuru et al., 2010; Ekpo, 2011; Longvah et al., 2011; Longvah et al., 2012; Xia et al., 2012; Enghoff et al., 2014; Assielou et al., 2015; Bauserman et al., 2015).

In 8 articles, possible hematic and growth alterations due to edible insect consumption were studied. One study focused on cholesterol content of *Imbrasia belina*, suggesting that the adverse effects of a high concentration of cholesterol could be mitigated by the presence of substantial amounts of β -sitosterol and campesterol in the insect. The others concluded that insect consumption does not have detrimental hepatic, renal or hematologic effects and that infants who consumed caterpillar have higher hemoglobin concentrations and fewer cases of anemia, suggesting that caterpillar cereal might have some beneficial effects (Zhou and Han, 2006; Longvah et al., 2012; Xia et al., 2012; Bauserman et al., 2015; Ogunleye, 2006; Yeboah and Mitei, 2009; Ekpo, 2011; Igwe et al., 2014).

In a study conducted in 1994, B. I. Adamolekun et al. reported a human epidemic of seasonal ataxia in Ikare (Western Nigeria) associated with the consumption of *Anaphe venata* Butler. The study described 34 patients who developed cerebellar ataxia, nystagmus and varying levels of impaired consciousness after consuming this insect (Adamolekun and Ibikunle, 1994).

Finally, 8 articles presented data on the possible pharmacological effects of edible insect consumption. Apart from antioxidant and integrator potential due to their nutrient and anti-nutrient composition, protein content and high calcium density, many insects have shown

specific properties that can be developed in the pharmaceutical sector nevertheless, possible risks for human health must be considered (Shantibala et al., 2014; Azad Thakur and Firake, 2012; Adámková et al., 2014). Two articles studied the possible use of edible insects (*Momordica charantia* L., *Myrmeleon* sp. and *Clanis bilineata*) as blood glucose--lowering agents for diabetic patients, confirming their potential as suitable alternative hypoglycemic agents for humans (Mujahid et al., 2013; Xia et al., 2013), while Cheseto et al. showed the potential of the desert locust, *Schistocerca gregaria*, as an unconventional source of dietary and therapeutic sterols (Cheseto et al., 2015). Enghoff et al. suggest that Diplopoda defensive secretions, hydrogen cyanide and benzoquinones, may act as insect repellents and that sub-lethal cyanide ingestion may enhance human's innate resistance to malaria, while Tang confirmed that Chinese black ants (*Polyrhachis dives*) contain compounds that display anti-inflammatory, immunosuppressive, and renoprotective activities (Enghoff et al., 2014; Tang et al., 2015),.

Animals

The majority of studies considering edible insects as feed for animals focus on three main risks: growth alteration, nutrient malabsorption and hematic and qualitative meat alteration.

Of the 30 articles reviewed in this group, 23 analyzed insects as possible feed for poultry, 3 for fish and 1 for rats.

Poultry

In 19 articles, the risk of growth alteration from poultry feed including various insect derivatives was studied. In one work, the incorporation of silkworm pupae meal into broiler diets at 5%, which replaced one-half of the fishmeal, significantly depressed growth rate and final body weight at 6 weeks old (Sudhakara Reddy et al., 1991). In all other studies reviewed, no

differences in growth rate or egg production were observed, and some authors even suggest significantly better growth of broilers (Gawaad and Brune, 1979; Ocio et al., 1979; Dhaliwal et al., 1980; Joshi et al., 1980; Virk et al., 1980; Sujatha and Rao, 1981; Gado et al., 1982; Nakagaki et al., 1987; Chrappa et al., 1990; Chrappa et al., 1990; Kumar et al., 1992; Atteh and Ologbenla, 1993; Despins and Axtell, 1995; Pro M. et al., 1999; Hwangbo et al., 2009; Aigbodion et al., 2012; Sun et al., 2012; Jadalla et al., 2014; Bovera et al., 2015).

Similar results were observed for malabsorption risk. Of the 17 studies analyzing the issue, only one suggested a slight decrease in feed efficiency due to the lower caloric density of diets containing dried pupae compared with those containing soybean oil meal (Koo et al., 1980). The majority of authors observed no difference, and in some cases, chickens fed larvae meal had higher average concentrations of calcium and lower serum concentrations of total lipids, glucose, cholesterol and inorganic phosphorus compared with controls (Gawaad and Brune, 1979; Ocio et al., 1979; Dhaliwal et al., 1980; Joshi et al., 1980; Virk et al., 1980; Sujatha and Rao, 1981; Gado et al., 1982; Kumar et al., 1992; Atteh and Ologbenla, 1993; Pro M. et al., 1999; Hwangbo et al., 2009; Sun et al., 2012; Jadalla et al., 2014; Bovera et al., 2015; Virk et al., 1980; DeFoliart et al., 1982).

In 6 articles, possible hematic or meat alterations in broilers fed insect-based diets were assessed, and none observed significant alterations (Gado et al., 1982; Kumar et al., 1992; Atteh and Ologbenla, 1993; Hwangbo et al., 2009; Sun et al., 2012; Bovera et al., 2015).

Other animals

Only 6 articles analyzed the risks associated with the replacement of traditional fish feed with insect-based feed (maggots, termites, grasshoppers, silkworm pupae and May flies). They did not

state specific risks but suggested a careful analysis of the anti-nutrients provided by such an insect-based diet (Fasakin et al., 2003; Sogbesan and Ugwumba, 2008; Tamale et al., 2010; Alegbeleye et al., 2012; Lee et al., 2012; Ji et al., 2015).

One article studied the effects of supplemental methionine and lysine on the nutritional value of housefly larvae meal (*Musca domestica*) fed to rats, concluding that housefly larvae meal seemed deficient in methionine and that supplementation with this amino acid was of tremendous benefit to the animals (Onifade et al., 2001).

DISCUSSION AND CONCLUSION

The vast heterogeneity of edible insects analyzed by studies deeply affects the output of this review.

It is clear that most recently, researchers have shifted their focus, moving away from the possible use of edible insects in animals feed to a protein and nutrient source for humans.

Humans

The risks to human health proposed and analyzed in the scientific literature are mainly related to allergy, microbiological and chemical contamination, malabsorption, and hematic alteration caused by edible insect consumption. The risk of allergic reaction due to the presence of allergens in insects is the only aspect showing overall concordance among authors, who identify a need for specific studies to investigate the existence of cross-reactive allergens. Nevertheless, such a risk is limited to the group of allergic persons and does not seems to be of higher impact compared to other more common foods, such as shellfish or mollusks. The second element noted by the results of this review is the need for more comprehensive studies on the role of the anti-nutrient factors often isolated from edible insects. In fact, their implications for human health are

still under discussion, especially in terms of concentrations, interactions with nutrient assimilation and potential pharmaceutical applications.

Studies on microbiological contamination risk showed considerable heterogeneity in the conclusion reached by authors. An important factor seems to be poor sanitation and inadequate collection, drying, transportation, storage and marketing conditions. A possible interpretation, considering the countries and counties wherein those studies were conducted, is that microbiological contamination is strictly area specific, presenting a higher risk in lower-resources settings, a common feature of many products from low-income countries. Other risks, such as malabsorption, hematic alteration and growth alterations, linked with insect consumption did not present major concerns, and many author suggested a potential role for edible insects in efficiently fighting famine and lack of protein availability in low-resources settings and stressed the use of insects in most traditional cuisines.

Animals

Most of the articles reviewed suggested that edible insects derivatives represent efficient and safe substitutes for other animal protein products. On the one hand, many authors suggested that insect-based feed for poultry affect neither the quality of the meat nor the growth rate or the egg size. On the other hand, it is often stressed that insect-based meal can increase the concentration of nutrients and decrease the concentration of cholesterol in broiler meat. The same consideration could apply to fish feed, although the small number of studies reviewed underlines the need for more specific analyses.

As with studies on humans, many authors noted the need for ad hoc studies to determine the roles of anti-nutrients and their possible implications for animal health.

Finally, one of the most interesting finding is the use of insects as a starting point to develop drugs. Potential hypocholesterolemic and hypoglycemic agents derived from some insects will probably require additional efforts to determine their possible uses for human health, and the antioxidant characteristic exhibited by some insects needs in-depth research to standardize their use in many therapies.

In conclusion, this review shows that the use of insects as food and feed appears to have many positive aspects from the economic, environmental and nutritional points of view. However, considerable research still needs to be conducted, in particular, on the aspects of allergy, nutritional and anti-nutritional composition and pharmaceutical use of edible insects.

REFERENCES

- Adámková A., Kouřimská L., Borkovcová M., Mlček J., Bednářová M. (2014). Calcium in edible insects and its use in human nutrition. *Potravinárstvo: Scientific Journal for Food Industry*, 8: 233-38
- Adamolekun B., Ibikunle F. R. (1994). Investigation of an epidemic of seasonal ataxia in Ikare, western Nigeria. *Acta neurologica Scandinavica*, 90: 309-11
- Adebowale Y. A., Adebowale K.O., Ogentokun M.O., (2005). Evaluation of nutritive properties of the large African cricket (Gryllidae sp). Karachi, PAKISTAN, Pakistan Council of Scientific and Industrial Research
- Adeduntan S. A. (2005). Nutritonal and antinutritional characteristics of some insects foraging in Akure forest reserve Ondo State, Nigeria. *Journal of Food Technology*, 3: 563-67
- Aigbodion F. I., Egbon I. N., Erukakpomren E. (2012). A preliminary study on the entomophagous response of *Gallus gallus domesticus* (Galliformes: Phasianidae) to adult *Periplaneta americana* (Blattaria: Blattidae). *International Journal of Tropical Insect Science*, 32: 123-25
- Alegbeleye W. O., Obasa S. O., Olude O. O., Otubu K., Jimoh W. (2012). Preliminary evaluation of the nutritive value of the variegated grasshopper (*Zonocerus variegatus* L.) for African catfish *Clarias gariepinus* (Burchell. 1822) fingerlings. *Aquaculture Research*, 43: 412-20
- Assielou B., Due E. A., Koffi M. D., Dabonne S., Kouame P. L. (2015). *Oryctes owariensis* larvae as good alternative protein source: nutritional and functional properties. *SCIENCEDOMAIN International*, 8: 1-9

- Atteh J. O., Ologbenla F. D. (1993). Replacement of fish meal with maggots in broiler diets: effects on performance and nutrient retention. *Nigerian Journal of Animal Production*, **20**: 44-49
- Azad Thakur N. S., Firake D. M. (2012). Ochrophora montana (Distant): a precious dietary supplement during famine in northeastern Himalaya. *Current Science* **102**: 845-46
- Barenes H., Phimmasane M., Rajaonarivo C. (2015). Insect Consumption to Address Undernutrition, a National Survey on the Prevalence of Insect Consumption among Adults and Vendors in Laos. *PloS one*, **10**: e0136458
- Barre A., Caze-Subra S., Gironde C., Bienvenu F., Bienvenu J., Rougé P. (2014). Entomophagie et risque allergique. *Revue Française d'Allergologie*, **54**: 315-21
- Bauserman M., Lokangaka A., Gado J., Close K., Wallace D., Kodondi K. K., Tshefu A., Bose C. (2015). A cluster-randomized trial determining the efficacy of caterpillar cereal as a locally available and sustainable complementary food to prevent stunting and anaemia. *Public health nutrition*, **18**: 1785-92
- Belluco S. (2009). Insetti per uso alimentare umano: aspetti nutrizionali e igienico-sanitari. Eds. Facoltà di Medicina Veterinaria, Università degli studi di Padova
- Belluco S., Losasso C., Maggioletti M., Alonzi C., Ricci A., Paoletti M. G. (2015). Edible insects: a food security solution or a food safety concern? *Animal Frontiers*, **5**: 25-30
- Bovera F., Piccolo G., Gasco L., Marono S., Loponte R., Vassalotti G., Mastellone V., Lombardi P., Attia Y. A., Nizza A. (2015). Yellow mealworm larvae (*Tenebrio molitor*, L.) as a possible alternative to soybean meal in broiler diets. *British poultry science*, **56**: 569-75

- Braide W., Nwaoguikpe R. N. (2010). Microbiological and nutritional status of an edible caterpillar (*Rhynchophorus phoenicis*). *Current Trends in Microbiology*, **6**: 61 - 68
- Broekman H., Knulst A., den Hartog Jager S., Monteleone F., Gaspari M., de Jong G., Houben G., Verhoeckx K. (2015). Effect of thermal processing on mealworm allergenicity. *Mol Nutr Food Res*, **59**: 1855-64
- Cheseto X., Kuate S. P., Tchouassi D. P., Ndung'u M., Teal P. E., Torto B. (2015). Potential of the Desert Locust *Schistocerca gregaria* (Orthoptera: Acrididae) as an Unconventional Source of Dietary and Therapeutic Sterols. *PloS one*, **10**: e0127171
- Chrappa V., Peter V., Straznicka H., Sabo V., Abelova H., Strozyk Z. (1990). Production effects of feeding housefly (*Musca domestica* L.) larvae and pupae to broiler chicks. *Scientia agriculturae bohemoslovaca*, **22**: 201-8
- Chrappa V., Peter V., Stróžýk Z., Slámečka J. (1990). The effects of the feeding of poultry dung cultured by housefly (*Musca domestica* L.) larvae on the efficiency of broiler chicks. *Scientia Agriculturae Bohemoslovaca*, **22**: 131-38
- Collavo A., Glew R. H., Huang Y. S., Chuang L. T., Bosse R., Paoletti M. G. (2005). House cricket small-scale farming.eds. Ecological implications of minilivestock: potential of insects, rodents, frogs and snails. Enfield, Science Publishers, Inc., 519-44
- DeFoliart G. R., Finke M. D., Sunde M. L. (1982). Potential value of the mormon cricket (Orthoptera: Tettigoniidae) harvested as a high-protein feed for poultry. *Journal of economic entomology*, **75**: 848-52
- Despins J. L., Axtell R. C. (1995). Feeding behavior and growth of broiler chicks fed larvae of the darkling beetle, *Alphitobius diaperinus*. *Poultry science*, **74**: 331-6

- Dhaliwal J. S., Virk R. S., Atwal A. S. (1980). The use of house fly (*Musca domestica* Linnaeus) pupae meal in broiler mash. *Indian Journal of Poultry Science*, **15**: 119-22
- Ekpo K. E. (2011). Effect of processing on the protein quality of four popular insects consumed in Southern Nigeria. *Archives of Applied Science Research*, **3**: 307-26
- Ekpo K. E. (2011). Nutritional and biochemical evaluation of the protein quality of four popular insects consumed in Southern Nigeria. *Archives of Applied Science Research*, **3**: 428-44
- Enghoff H., Manno N., Tchibozo S., List M., Schwarzingen B., Schoefberger W., Schwarzingen C., Paoletti M. G. (2014). Millipedes as food for humans: their nutritional and possible antimalarial value-a first report. *Evidence-based complementary and alternative medicine : eCAM*, **2014**: 651768
- Fasakin E. A., Balogun A. M., Ajayi O. O. (2003). Evaluation of full-fat and defatted maggot meals in the feeding of clariid catfish *Clarias gariepinus* fingerlings. *Aquaculture Research*, **34**: 733-38
- Fontaneto D., Tommaseo-Ponzetta M., Galli C., Risé P., Glew R. H., Paoletti M. G. (2011). Differences in Fatty Acid Composition between Aquatic and Terrestrial Insects Used as Food in Human Nutrition. Ecology of Food and Nutrition. *Ecology of Food and Nutrition*, **50**: 351-67
- Gado M. S., El Aggory S. M., Abd El Gawaad A. A., Mahmoud A. K. (1982). The possibility of applying insect protein in broiler rations. *Research Bulletin - Ain-Shams University*
- Gawaad A. A. A., Brune H. (1979). Insect Protein as a Possible Source of Protein to Poultry1. *Zeitschrift für Tierphysiologie Tierernährung und Futtermittelkunde*, **42**: 216-22

Hernandez-Flores L., Llanderal-Cazares C., Guzman-Franco A. W., Aranda-Ocampo S. (2015).

Bacteria Present in Comadia redtenbacheri Larvae (Lepidoptera: Cossidae). *J Med*

Entomol, **52**: 1150-8

Hwangbo J., Hong E. C., Jang A., Kang H. K., Oh J. S., Kim B. W., Park B. S. (2009).

Utilization of house fly-maggots, a feed supplement in the production of broiler chickens.

Journal of environmental biology / Academy of Environmental Biology, India, **30**: 609-14

Hyun S.H., Kwon K. H., Park K.-H., Jeong H. C., Kwon O., Tindwa H., Han Y. S. (2012).

Evaluation of nutritional status of an edible grasshopper, Oxya Chinensis Formosana.

Entomological Research, **42**: 284-90

Igwe C. U., Ojiako A. O., Okwara J. E., Emejulu A. A., Nwaoguikpe R. N. (2014). Biochemical

and haematologic effects of intake of Macrotermes nigeriensis fortified functional diet.

Pakistan journal of biological sciences : PJBS, **17**: 282-6

Jadalla J. B., Habbani A. M. H., Bushara I., Mekki D. M. (2014). Effects of inclusion of different

levels of watermelon bug meal in broiler rations on feed intake, body weight changes and

feed conversion ratio in North Kordofan, Sudan. *Scientific Journal of Animal Science* **3**:

8-14

Ji H., Zhang J., Huang J., Cheng X., Liu C. (2015). Effect of replacement of dietary fish meal

with silkworm pupae meal on growth performance, body composition, intestinal protease

activity and health status in juvenile Jian carp (Cyprinus carpio var. Jian). *Aquaculture*

Research, **46**: 1209-21

Joshi P. S., Rao P. V., Mitra A., Rao B. S. (1980). Evaluation of deoiled silkworm pupae-meal

on layer performance. *Indian Journal of Animal Sciences*, **50**: 979-82

- Kinyuru J. N., Kenji G. M., Njoroge S. M., Ayieko M. (2010). Effect of Processing Methods on the In Vitro Protein Digestibility and Vitamin Content of Edible Winged Termite (*Macrotermes subhyllanus*) and Grasshopper (*Ruspolia differens*). *Food Bioprocess Technol*, **3**: 778-82
- Klein R. G. (2009). The human career. Human biological and cultural origins. 3rd ed. Chicago and London, The University of Chicago Press
- Klunder H. C., Wolkers-Rooijackers J., Korpela J. M., Nout M. J. R. (2012). Microbiological aspects of processing and storage of edible insects. *Food Control*, **26**: 628-31
- Koc K., Incekara U., Turkez H. (2014). Biomonitoring of the genotoxic effects and oxidative potentials of commercial edible dung beetles (*Onitis* sp.), grasshopper (*Caelifera* sp.) and mole crickets (*Gryllotalpa* sp.) in vitro. *Toxicol Ind Health*, **30**: 683-9
- Koo S. I., Currin T. A., Johnson M. G., King E. W., Turk D. E. (1980). The Nutritional Value and Microbial Content of Dried Face Fly Pupae (*Musca autumnalis* (De Geer)) When Fed to Chicks. *Poult Sci*, **59**: 2514-18
- Kumar A., Hasan S. B., Rao R. J. (1992). Studies on the performance of broilers fed on silkworm moth meal. *International Journal of Animal Sciences*, **7**: 227-29
- Lee J., Choi I. C., Kim K. T., Cho S. H., Yoo J. Y. (2012). Response of dietary substitution of fishmeal with various protein sources on growth, body composition and blood chemistry of olive flounder (*Paralichthys olivaceus*, Temminck & Schlegel, 1846). *Fish physiology and biochemistry*, **38**: 735-44

- Longvah T., Mangthya K., Qadri S. S. (2012). Eri silkworm: a source of edible oil with a high content of alpha-linolenic acid and of significant nutritional value. *J Sci Food Agric*, **92**: 1988-93
- Longvah T., Mangthya K., Ramulu P. (2011). Nutrient composition and protein quality evaluation of eri silkworm (*Samia ricinii*) prepupae and pupae. *Food Chem*, **128**: 400-3
- Lundy M. E., Parrella M. P. (2015). Crickets are not a free lunch: protein capture from scalable organic side-streams via high-density populations of *Acheta domesticus*. *PloS one*, **10**: e0118785
- Memis E., Turkez H., Incekara U., Banjo A. D., Fasunwon B. T., Togar B. (2013). In vitro biomonitoring of the genotoxic and oxidative potentials of two commonly eaten insects in southwestern Nigeria. *Toxicol Ind Health*, **29**: 52-9
- Mujahid M. Z., Agistia D. D., Sa'adah M., Nugroho A. E. (2013). A combination of bitter melon ethanolic extract with ant lion larvae aqueous extract for a blood glucose-lowering agent. *International Food Research Journal*, **20**: 851-55
- Musundire R., Zvidzai C. J., Chidewe C., Samende B. K., Manditsera F. A. (2014). Nutrient and anti-nutrient composition of *Henicus whellani* (Orthoptera: Stenopelmatidae), an edible ground cricket, in south-eastern Zimbabwe. *International Journal of Tropical Insect Science*, **34**: 223-31
- Nakagaki B. J., Sunde M. L., Defoliart G. R. (1987). Protein Quality of the House Cricket, *Acheta domesticus*, When Fed to Broiler Chicks. *Poult Sci*, **66**: 1367-71
- Ocio E., Viñaras R., Rey J. M. (1979). House fly larvae meal grown on municipal organic waste as a source of protein in poultry diets. *Animal Feed Science and Technology*, **4**: 227-31

Ogunleye R. F. (2006). Biochemical implications of the consumption of *Zonocerus variegatus*, (Orthoptera: Notodontidae) and *Cirina forda* Westwood (Lepidoptera: Saturniidae).

Journal of Food Agriculture and Environment, **4**: 23-25

Omotoso O. T., Afolabi O. (2007). Nutritional evaluation, functional properties and anti-nutritional factors of *Macrobrachium rosenbergii*, an underutilized animal. *Pakistan*

Journal of Scientific and Industrial Research, **50**: 109-12

Omotoso O. T. (2015). Nutrient composition, mineral analysis and anti-nutrient factors of *Oryctes rhinoceros* L. (Scarabaeidae: Coleoptera) and winged termites, *Macrotermes nigeriensis* Sjostedt. (Termitidae: Isoptera). *British Journal of Applied Science &*

Technology, **8**: 97-106

Omotoso O. T. (2006). Nutritional quality, functional properties and anti-nutrient compositions of the larva of *Cirina forda* (Westwood) (Lepidoptera: Saturniidae). *Journal of Zhejiang*

University Science B, **7**: 51-5

Onifade A. A., Oduguwa O. O., Fanimio A. O., Abu A. O., Olutunde T. O., Arije A., Babatunde G. M. (2001). Effects of supplemental methionine and lysine on the nutritional value of housefly larvae meal (*Musca domestica*) fed to rats. *Bioresource technology*, **78**: 191-4

Oonincx D. G., van Itterbeeck J., Heetkamp M. J., van den Brand H., van Loon J. J., van Huis A. (2010). An exploration on greenhouse gas and ammonia production by insect species

suitable for animal or human consumption. *PloS one*, **5**: e14445

- Payne C. L. R., Scarborough P., Rayner M., Nonaka K. (2016). A systematic review of nutrient composition data available for twelve commercially available edible insects, and comparison with reference values. *Trends in Food Science & Technology*, **47**: 69-77
- Pro M. A., Cuca G. M., Becerril P. C., Bravo M. H., Bixler C. E., Pérez H. A. (1999). Estimation of metabolizable energy and utilization of fly larvae (*Musca domestica* L.) in the feeding of broilers. *Archivos Latinoamericanos de Producción Animal*, **7**: 39-51
- Routh S., Routh J. (2005). Note di cucina di Leonardo da Vinci. Roma, Voland
- Shantibala T., Lokeshwari R. K., Debaraj H. (2014). Nutritional and antinutritional composition of the five species of aquatic edible insects consumed in Manipur, India. *Journal of insect science*, **14**: 14
- Simpanya M. F., Allotey J., Mpuchane S. F. (2000). A mycological investigation of phane, an edible caterpillar of an emperor moth, *Imbrasia belina*. *J Food Prot*, **63**: 137-40
- Sogbesan A. O., Ugwumba A. A. A. (2008). Nutritional evaluation of termite (*Macrotermes subhyalinus*) meal as animal protein supplements in the diets of *Heterobranchius longifilis* (Valenciennes, 1840) fingerlings. *Turkish Journal of Fisheries and Aquatic Sciences*, **8**: 149-57
- Srinroch C., Srisomsap C., Chokchaichamnankit D., Punyarit P., Phiriyangkul P. (2015). Identification of novel allergen in edible insect, *Gryllus bimaculatus* and its cross-reactivity with *Macrobrachium* spp. allergens. *Food chemistry*, **184**: 160-6

- Sudhakara Reddy P., Nakahari D., Talukdas J. K., Sundararasu V. (1991). Effect of mineral supplementation on the nutritive value of silkworm pupae meal in broiler feeds. *Cheiron*, **20**: 106
- Sujatha K. R., Rao B. S. (1981). Feasibility of substituting fishmeal by alternative protein sources in layer rations. *Indian Journal of Poultry Science*, **16**: 350-57
- Sun T., Long R. J., Liu Z. Y., Ding W. R., Zhang Y. (2012). Aspects of lipid oxidation of meat from free-range broilers consuming a diet containing grasshoppers on alpine steppe of the Tibetan Plateau. *Poultry science*, **91**: 224-31
- Tamale A., Sifuna T., Mwangi K., Ayieko M., Ndonga M. (2010). Use of mayflies as total replacement of *Rastrineobola argentea* in diets for catfish, *Clarias gariepinus* in Lake Victoria basins. [^]eds. Ethnobotany and Health Proceedings of the Cluster Workshop. Entebbe, Uganda, Inter-University Council for East Africa Lake Victoria Research Initiative, 178-84
- Tang J.J., Fang P., Xia H.-L., Tu Z.-C., Hou B.-Y., Yan Y.-M., Di L., Zhang L., Cheng Y.-X. (2015). Constituents from the edible Chinese black ants (*Polyrhachis dives*) showing protective effect on rat mesangial cells and anti-inflammatory activity. *Food Research International*, **67**: 163-68
- Tommaseo-Ponzetta M., Paoletti M. G. (2005). Lessons from Traditional Foraging Patterns in West Papua (Indonesia). Ecological implications of minilivestock: potential of insects, rodents, frogs and snails. Enfield, Science Publishers, Inc., 441-57

- Turkez H., Incekara U., Guner A., Aydin E., Dirican E., Togar B. (2014). The cytogenetic effects of the aqueous extracts of migratory locust (*Locusta migratoria* L.) in vitro. *Toxicol Ind Health*, **30**: 233-7
- van Huis A. (2013). Edible insects : future prospects for food and feed security. Rome, Food and Agriculture Organization of the United Nations
- Verhoeckx K. C. M., van Broekhoven S., den Hartog-Jager C. F., Gaspari M., de Jong G. A. H., Wichers H. J., van Hoffen E., Houben G. F., Knulst A. C. (2014). House dust mite (Der p 10) and crustacean allergic patients may react to food containing Yellow mealworm proteins. *Food and Chemical Toxicology*, **65**: 364-73
- Virk R. S., Lodhi G. N., Ichhponani J. S. (1980). Deoiled silk worm pupae meal as a substitute for fish meal in White Leghorn laying ration. *Indian Journal of Poultry Science*, **15**: 149-54
- Virk R. S., Lodhi G. N., Ichhponani J. S. (1980). Nutritive value of untreated, water and acid treated deoiled silk worm pupae meal for broiler chicks. *Indian Journal of Poultry Science*, **15**: 155-61
- Xia Z., Chen J., Wu S. (2013). Hypolipidemic activity of the chitooligosaccharides from *Clanis bilineata* (Lepidoptera), an edible insect. *International journal of biological macromolecules*, **59**: 96-8
- Xia Z., Wu S., Pan S., Kim J. M. (2012). Nutritional evaluation of protein from *Clanis bilineata* (Lepidoptera), an edible insect. *Journal of the science of food and agriculture*, **92**: 1479-82

Yeboah S. O., Mitei Y. C. (2009). Further Lipid Profiling of the Oil from the Mophane

Caterpillar, *Imbrasia belina*. *J Am Oil Chem Soc*, **86**: 1047-55

Zhou J., Han D. (2006). Safety evaluation of protein of silkworm (*Antheraea pernyi*) pupae.

Food and chemical toxicology, **44**: 1123-30

Table 1: Articles included for final review

	Auth ors	Y ea r	Title	Type of insect	Huma n/ani mal	Type of consu mption	Main risks analyzed *	Sp ecif ic ris k y/n	Pharma cologica l effect	Main results
1	A. A. A. Gawa ad et al.	1 9 7 9	Insect protein as a possible source of protein to poultry. 1. Introducti on and statement of the problem	<i>Musca domest ica L.</i> and <i>Phormi a terraen ovae R.-D</i>	Anima l (poultr y)	Prolo nged	Ma lab sor pti on ris k Gr ow th alt era tio n	n -		Larval meal could be a suitable feedstuff for broiler productio n.

							ris k			
2	E. Ocio et al.	1979	House fly larvae meal grown on municipal organic waste as a source of protein in poultry diets	<i>Musca domestica</i> L	Animal (poultry)	Prolonged	Malabsorption risk	n	-	Results showed no significant difference in body weight gain or food conversion efficiency.
3	J. S. Dhaliwal	1998	The use of house fly	<i>Musca domestica</i>	Animal (poultry)	Prolonged	Malabsorption	n	-	50 per cent replacement

	et al.	0	(Musca domestic a Linnaeus) pupae meal in broiler mash	ica L	y)		pti on ris k Gr ow th alt era tio n ris k			nt of fish meal by house fJy pupae in the poultry ration may be adopted without any adverse effect on the performa nce of the birds.
4	P. S. Joshi et al.	1 9 8 0	Evaluatio n of deoiled silkworm	Silkwo rm pupae	Anima l (poultr y)	Prolo nged	Ma lab sor pti	n	-	Egg size was not affected by insect

			pupae-meal on layer performance				on risk Growth alteration in risk			based feed.
5	S. I. Koo et al.	1980	The nutritional value and microbial content of dried face fly pupae	<i>Musca autumnalis</i>	Animal (poultry)	Prolonged	Malabsorption risk	y	-	Dried pupae of <i>M. autumnalis</i> could be used to extract nutrients in dung

			(Musca autumnalis (De Geer)) when fed to chicks							and could be used as a feed extender and protein source.
6	R. S. Virk et al.	1980	Deoiled silk worm pupae meal as a substitute for fish meal in White Leghorn laying ration	Silkworm pupae	Animal (poultry)	Prolonged	Malabsorption risk	n	-	SWP had no significant effect on egg production.
7	R. S. Virk	19	Nutritive value of	Silkworm	Animal	Prolonged	Malabsorption risk	n	-	The effects of

		80	untreated, water and acid treated deoiled silk worm pupae meal for broiler chicks	pupae	(poultry)		seroprevalence risk			SWP on growth and in production performance are good.
8	K. R. Sujatha et al.	1981	Feasibility of substituting fishmeal by alternative	Silkworm pupae	Animal (poultry)	Prolonged	Mass lab seroprevalence risk	n	-	There was no significant difference among treatment

			e protein sources in layer rations				Gr ow th alt era tio n ris k			groups in egg productio n, feed intake, egg weight, bodyweig ht or financial returns.
9	G. R. DeFo liart et al.	1 9 8 2	Potential value of the mormon cricket (Orthoptera: Tettigoniidae) harvested	Mormon cricket	Animal (poultry)	Prolo nged	Malabsorption risk	n	-	Diets based on maize and crickets produced significantly better growth of broiler chicks

			as a high-protein feed for poultry							than a conventional diet based on maize and soyabean.
10	M. S. Gado et al.	1982	The possibility of applying insect protein in broiler rations	<i>Musca domestica</i>	Animal (poultry)	Prolonged	Malabsorption risk Growth alteration tion n ris	n	-	Chickens given larvae meal had higher average concentrations of calcium and lower concentrations of total lipids, glucose,

							k			cholesterol and inorganic phosphorus in blood serum compared with controls; total protein was not affected. Birds given larvae meal had greater weights of edible and
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										inedible parts of the carcass, giblets and body fat, and lower weight of feathers compared with control birds.
1 1	B. J. Naka gaki, et al.	1 9 8 7	Protein quality of the house cricket, Acheta domestica, when	House cricket (<i>Acheta domestica</i>)	Animal (poultry)	Prolonged	Growth alteration risk	n	-	There were no significant differences in weight

			fed to broiler chicks							gain between chicks fed on maize/soy abean meal diets and those fed on maize/cricket diets.
1 2	V. Chra ppa et al.	1 9 9 0	The effects of the feeding of poultry dung cultured by housefly (<i>Musca</i>	<i>Musca</i> <i>domest</i> <i>ica L.</i>	Anima l (poultr y)	Prolo nged	Growth alteration risk	n	-	Results indicated that 3 or 5% dried poultry manure containin g housefly larvae

			domestic a L.) larvae on the efficiency of broiler chicks							was a suitable feed for broiler chicken.
1 3	V. Chra ppa et al.	1 9 9 0	Productio n effects of feeding housefly (<i>Musca</i> domestic a L.) larvae and pupae to broiler chicks	<i>Musca</i> <i>domest</i> <i>ica L.</i>	Anima l (poultr y)	Prolo nged	Growth alteration risk	n	-	Results indicated that when feeds of animal origin are replaced by housefly pupae and/or larvae, there are no

										negative effects on chick growth efficiency, nor on the quality and taste of the meat of the birds reared on these diets.
14	P. Sudh akara Redd y et al.	1991	Effect of mineral supplementation on the nutritive	Silkworm pupae	Animal (poultry)	Prolonged	Growth alteration risk	y	-	Incorporation of silkworm pupae meal (SWPM)

			value of silkworm pupae meal in broiler feeds							in broiler diets at 5%, replacing half of the fish meal, significan tly depressed growth rate, and final body weight at 6 weeks old, leading to poorer feed efficiency , higher cost of productio
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										n and lower broiler farm economy index
1 5	A. Kumar et al.	1 9 9 2	Studies on the performa nce of broilers fed on silkworm moth meal	Silkworm	Animal (poultry)	Prolonged	Malabsorption Growth alteration ris	n	-	Silkworm moth meal can be successfully used as a source of animal protein in broiler feeds.

							k He ma tic an d qu alit ati ve me at alt era tio n ris k			
1 6	J. O. Atteh et al.	1 9 9	Replacem ent of fish meal	<i>Musca</i> <i>domest</i> <i>ica</i>	Anima l (poultr	Prolo nged	Ma lab sor	n	-	Maggots could replace

		3	with maggots in broiler diets: effects on performa nce and nutrient retention		y)		pti on ris k Gr ow th alt era tio n ris k He ma tic an d qu alit ati ve			33% of dietary fish meal without compromi sing performa nce and are an economic al replaceme nt
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							me at alt era tio n ris k			
1 7	B. Ada mole kun et al.	1 9 9 4	Investigat ion of an epidemic of seasonal ataxia in Ikare, western Nigeria	<i>Anaph e venata Butler</i>	Human	Singu lar	Risk of developin g ataxia after consumpti on	y	-	Consumpt ion of the roasted larvae of Anaphe venata Butler could cause cerebellar ataxia, nystagmu s and

										varying levels of impaired consciousness.
18	J. L. Despins et al.	1995	Feeding behavior and growth of broiler chicks fed larvae of the darkling beetle, <i>Alphitobius diaperinus</i>	<i>Alphitobius diaperinus</i>	Animal (poultry)	Prolonged	Growth alteration risk	n	-	The body weight of chicks feeding on starter feed and larvae was significantly greater than the weight of chicks consuming feed only.

19	M.A. Pro et al.	1999	Estimation of metabolizable energy and utilization of fly larvae (Musca domestica L.) in the feeding of broilers	<i>Musca domestica L.</i>	Animal (poultry)	Prolonged	Malabsorption on risk	n	-	Protein and energy supplied by the dry fly larvae support animal performance similar to that of chicks fed a conventional diet
20	M. F. Simp any et al.	2000	A mycological investigation of	<i>Imbras ia belina</i>	Non specific	Prolonged	Microbiology	y	-	Risk of recontamination of phane during

			phane, an edible caterpill r of an emperor moth, Imbrasia belina				l co nta mi nat ion ris k			drying and storage.
2 1	A. A. Onifa de et al.	2 0 0 1	Effects of suppleme ntal methioni ne and lysine on the nutritiona l value of housefly larvae meal (Musca	<i>Musca domest ica L</i>	Anima l (rats)	Non specif ic	He ma tic an d qu alit ati ve me at alt era	y	-	Housefly larvae meal seemed deficient in methionin e and it benefited the rat tremendo usly to suppleme

			domestic a) fed to rats				tio n ris k			nt with this amino acid
2 2	E. A. Fasak in et al	2 0 0 3	Evaluatio n of full- fat and defatted maggot meals in the feeding of clariid catfish Clarias gariepinu s fingerling s	Maggo ts	Anima l (fish)	Prolo nged	Ma lab sor pti on ris k Gr ow th alt era tio n ris k	n y -		Fish performe d better when fed diets containin g defatted maggot meals than full- fat maggot meal, and compared favourabl y with fish fed

										the fish meal-based diet.
23	S. A. Adeduntan	2005	Nutritional and antinutritional characteristics of some insects foraging in Akure forest reserve Ondo State, Nigeria	Ant, termite, cricket, meal bug, grassopper, anaphevenata, tree hopper, winget termite	Non specific	Prolonged	Chemical contamination risk Ma lab sorption	y -	More work is needed to ascertain the impact of processing on the levels of nutrient and antinutritional factors (tannin and phytate)	

							k			
24	Y.A. Adebowale et al.	2005	Evaluation of nutritive properties of the large African cricket (<i>Gryllidae</i> sp)	African cricket	Non specific	Non specific	Malabsorption risk	n	-	Results of the in vitro protein multienzyme digestibility indicated high digestibility.
25	R. F. Ogunleye	2006	Biochemical implications of the consumption of <i>Zonocerus</i>	<i>Zonocerus variegatus</i> , and <i>Cirina fforda</i> Westw	Human	Prolonged	Growth alteration	n	-	No significant alteration in growth, cholesterol and glucose

			variegatu s, (Orthopte ra: Notodont idae) and Cirina forda Westwoo d (Lepidopt era: Saturnida e)	<i>ood</i>			k He ma tic an d qu alit ati ve me at alt era tio n ris k			levels were observed.
2 6	O.T. Omot oso	2 0 0	Nutrition al quality, functiona	<i>Larvae of Cirina</i>	Non specifi c	Non specif ic	Malabsorp tion risk	n	-	The results of anti-

		6	l properties and anti- nutrient compositi ons of the larva of Cirina forda (Westwo od) (Lepidopt era: Saturniid ae)	<i>forda</i>						nutritiona l analysis revealed that oxalate and phytic acid fell within nutritiona lly accepted values. Tannin was not detected
2 7	J. Zhou et al.	2 0 0 6	Safety evaluatio n of protein of silkworm	Silkwo rm pupae	Non specifi c	prolo nged	Gr ow th alt era	n	-	No statisticall y significan t

		(Antherae a pernyi) pupae					tio n ris k Ma lab sor pti on ris k He ma tic an d qu alit ati ve me at			difference s had been found in body weights, food consumpt ion and food efficiency of rats in each test group (P > 0.05)
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							alt era tio n ris k			
2 8	O.T. Omot oso et al.	2 0 0 7	Nutrition al evaluatio n, functiona l properties and anti- nutritiona l factors of Macrobra chium rosenberg ii, an	<i>Macro brachi um rosenb ergii</i>	Non specifi c	Non specif ic	Malabsorp tion risk	y	-	Three anti- nutrients were determine d: phytic acid was 4.00 ±0.01 mg/100 g, oxalate 1.05 ±0.00 mg/100 g while

			underutilized animal							tannin was not detected.
29	A.O. Sogbesan et al.	2008	Nutritional evaluation of termite (Macrotermes subhyalinus) meal as animal protein supplements in the diets of Heterobranchus longifilis (Valencie	Termite	Animal (fish)	Non specific	Malabsorption risk Growth alteration tion n risk	n -	50% inclusion levels of termite meal will yield the best result in a practical diet for H. longifilis fingerlings for a profitable and sustainabl	

			nnes, 1840) fingerling s							aquacultu re venture.
3 0	J. Hwa ngbo et al.	2 0 0 9	Utilizatio n of house fly- maggots, a feed suppleme nt in the productio n of broiler chickens	House fly- maggot s	Anima l (poultr y)	Prolo nged	Gr ow th alt era tio n ris k Ma lab sor pti on ris k He	n	-	Feeding diets containin g 10 to 15% maggots in chicken dropping after biodegrad ation can improve the carcass quality and

							ma tic an d qu alit ati ve me at alt era tio n ris k			growth performa nce of broiler chickens.
3 1	S. O. Yebo ah et al.	2 0 0 9	Further lipid profiling of the oil from the	<i>Imbras ia belina</i>	Non specifi c	Non specif ic	Hematic and qualitative meat alteration	y	-	Adverse effect of the high cholesterol content

			mophane caterpillar, Imbrasia belina				risk			given by <i>Imbrasia belina</i> could be mitigated by the presence of the substantial amounts of β-sitosterol and campesterol
32	W. Braid et al.	2010	Microbiological and nutritional status of an edible	<i>Rhynchosiphon phoenicis</i>	Human	Non specific	Microbiology	-	Poor sanitation and inadequate storage and	

			caterpillars (<i>Rhynchophorus phoenicis</i>)				contamination risk Chemical contamination risk			marketing conditions may contribute to the contamination and re-contamination of the products
33	J. N. Kinyuru et	201	Effect of processing	<i>Macrotremes subhyl</i>	Human	Non specific	Malabsorption risk	y	-	The processing

	al.	0	methods on the in vitro protein digestibili ty and vitamin content of edible winged termite (Macroter mes subhylan us) and grasshop per (Ruspolia differens)	<i>anus</i> and <i>Ruspol</i> <i>ia</i> <i>differe</i> <i>ns</i>						methods of the insects affected their nutrient potential as evidenced by the changes in protein digestibili ty and vitamins content
3 4	K. E. Ekpo	2 0	Nutrition al and	<i>Orycte</i> <i>s</i>	Non specifi	Prolo nged	Ma lab	n	-	Studied insects

		11	biochemical evaluation of the protein quality of four popular insects consumed in Southern Nigeria	<i>rhinoceros, Gonimbrasia belina, Macrotermes belicosus and Rhynchophorus phoenicis</i>	c		sortition risk			are good sources of essential nutrients, which could go a long way in helping to solve most nutritional problems in many developing countries.
35	K. E. Ekpo	201	Effect of processing on the	<i>Oryctes rhinoceros</i>	Non specific	Non specific	Hematinic	n	-	Insects are good sources of

		1	protein quality of four popular insects consume d in Southern Nigeria	<i>eros,</i> <i>Gonim</i> <i>brasia</i> <i>belina,</i> <i>Macrot</i> <i>ermes</i> <i>belicos</i> <i>us and</i> <i>Rhynch</i> <i>ophoru</i> <i>s</i> <i>phoeni</i> <i>cis</i>			an d qu alit ati ve me at alt era tio n ris k Gr ow th alt era tio n ris		essential nutrients
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							k			
36	T. Long vah et al	2011	Nutrient composition and protein quality evaluation of eri silkworm (Samia ricinii) prepupae and pupae	Eri silkworm	Non specific	Non specific	Ma lab sorpti on ris k	n		Protein digestibility corrected amino acid score (PDCAAS) was 86
37	F. I. Aigbodion et al.	2012	A preliminary study on the entomophagous response	<i>Blattaria: Blattidae</i>	Ainimal (poultry)	Prolonged	Gr ow th alt era tio n	n	-	Insect-enhanced meals could be used as an alternative feed

			of Gallus gallus domestic us (Gallifor mes: Phasianid ae) to adult Periplane ta american a (Blattaria : Blattidae)				ris k			within the formative stage of developm ent of G. domesticu s
3 8	W. O. Aleg beley e et	2 0 1 2	Prelimina ry evaluatio n of the nutritive	<i>Zonoce rus varieg atus</i>	Anima l (fish)	Prolo nged	Ma lab sor pti on	n	-	The results indicate that apparent

	al.		value of the variegate d grasshop per (Zonocer us variegatu s L.) for African catfish Clarias gariepinu s (Burchell . 1822) fingerling s				ris k Gr ow th alt era tio n ris k			protein and lipid digestibili ty were high at all levels, although there were decreases with an increase in the inclusion levels
3 9	S.H. Hyun	2 0	Evaluatio n of	<i>Oxya chinen</i>	Human	Non specif	Ma lab	n	-	It would be

	et al.	1	nutritiona	sis		ic	sor			recomme
		2	l status of	<i>formos</i>			pti			nded to
			an edible	<i>ana</i>			on			use the
			grasshop				ris			grasshopp
			per, Oxya				k			er (OCF)
			chinensis				Ch			as
			formosan				em			substitute
			a				ica			to the
							l			traditional
							co			sources of
							nta			protein.
							mi			
							nat			
							ion			
							ris			
							k			
4 0	H. C. Klun der et al.	2 0 1 2	Microbiol ogical aspects of processin g and	Farme d mealw orm larvae	Non specifi c	Non specif ic	Mi cro bio log ica	n	-	Simple preservati on methods such as

			storage of edible insects	and house cricket s			l co nta mi nat ion ris k			drying/aci difying without use of a refrigerat or were demonstr ated effective in safeguard ing shelf- life and safety by the control of - Enterobac teria -and bacterial - -spores.
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41	J. Lee et al	2012	Response of dietary substitution of fishmeal with various protein sources on growth, body composition and blood chemistry of olive flounder (Paralichthys olivaceus),	Silkworm pupae	Animal (fish)	Prolonged	Malabsorption	Granth-	Dietary substitution of fishmeal Silkworm pupae based feed could be made.
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			Temminck & Schlegel, 1846							
42	T. Longvah et al.	2012	Eri silkworm : a source of edible oil with a high content of alpha-linolenic acid and of significant nutritional value	Eri silkworm	Non specific	Prolonged	Maturation risk Grower health alteration in risk Her	n	-	The study showed that eri silkworm pupae oil is safe and nutritionally equivalent to commonly used vegetable oils.

							ma tic an d qu alit ati ve me at alt era tio n ris k			
4 3	T. Shant ibala et al.	2 0 1 2	Nutrition al and antinutriti onal compositi	<i>Lethoc erus indicus</i> ,, <i>Laccot</i>	Human	Non specif ic	Ch em ica l co	n	<i>C. tripunct atus</i> possesse d strong	Edible insects are rich in protein, fat,

			on of the five species of aquatic edible insects consume d in Manipur, India	<i>rephes</i> <i>macula</i> <i>tus</i> , <i>Hydro</i> <i>philus</i> <i>olivace</i> <i>ous</i> , <i>Cybiste</i> <i>r</i> <i>tripunc</i> <i>tatus</i> and <i>Crocot</i> <i>hemis</i> <i>servilia</i>			nta mi nat ion ris k		antioxid ant activity	carbohydr ates, minerals, and other activated elements that promote human health.
4 4	T. Sun et al.	2 0 1 2	Aspects of lipid oxidation of meat from free-	Grassh oppers	Anima l (poultr y)	Prolo nged	Ma lab sor pti on ris	n -		Meat in free-range broilers feeding on grasshopp

			range broilers consumin g a diet containin g grasshop pers on alpine steppe of the Tibetan Plateau				k He ma tic an d qu alit ati ve me at alt era tio n ris k			ers has more antioxidat ive potential and longer storage life.
4 5	A. Tama le et	2 0 1	Use of mayflies as total	May flies	Anima l (fish)	Prolo nged	Gr ow th	n	-	The analysis of the

	al.	2	replacem ent of Rastrineo bola argentea in diets for catfish, Clarias gariepinu s in Lake Victoria basin				alt era tio n ris k		conversio n ratio, suggest that May flies are a perfect replaceme nt for the fishmeal in the fish diets.
4 6	N.S. Azad Thak ur et al.	2 0 1 2	Ochropho ra montana (Distant): a precious dietary suppleme	<i>Ochro phora montan a</i>	Human	Non specif ic	-	-	Medicin al value and nutrient composi tion of different Thangna

			nt during famine in northeast ern Himalaya						ng- based tradition al products should be studied to determin e its benefits as a food source	
4 7	Z. Xia et al.	2 0 1 2	Nutrition al evaluatio n of protein from	<i>Clanis bilinea ta</i>	Non specifi c	Prolo nged	Ma lab sor pti on ris	n -		CBP may be a suitable alternativ e dietary protein

			Clanis bilineata (Lepidopt era), an edible insect				k He ma tic an d qu alit ati ve me at alt era tio n ris k			source for humans
4 8	E. Mem is et	2 0 1	In vitro biomonit oring of	<i>Zonoce rus varieg</i>	Human	Non specif ic	Chemical contamina tion risk	y	-	Studied insects can be

	al.	3	the genotoxic and oxidative potentials of two commonl y eaten insects in southwest ern Nigeria	<i>atus</i> and <i>Orycte</i> <i>s boas</i>						consumed safely, but it is necessary to consider the cellular damages that are likely to appear dependin g on the oxidative stress.
4 9	M. Z. Muja hid et al	2 0 1 3	A combinati on of bitter gourd	<i>Momor</i> <i>dica</i> <i>charan</i> <i>tia L.</i> and	Human	Non specif ic	-	-	The result indicate d that the	-

			ethanolic extract with ant lion larvae aqueous extract for a blood glucose- lowering agent	<i>Myrme leon sp.</i>					combina tion of bitter gourd and ant lion larvae is potential to be develop ed as a blood glucose- lowering agent for diabetic patients	
5 0	Z. Xia et al.	2 0 1	Hypolipi demic activity	<i>Clanis bilinea ta</i>	Human	Non specif ic	-	-	The results suggest	-

		3	of the chitoolig osacchari des from Clanis bilineata (Lepidopt era), an edible insect						that LCBL I may be a suitable alterativ e hypolipi demic source for humans.	
5 1	A. Adá mkov á et al.	2 0 1 4	Calcium in edible insects and its use in human nutrition	<i>Lethoc erus indicus</i> , <i>Laccot rephes macula tus</i> , <i>Hydro</i>	Non specifi c	Non specif ic	-	-	Selected species of edible insect could serve as an alternati ve	-

				<i>philus</i> <i>olivace</i> <i>ous,</i> <i>Cybiste</i> <i>r</i> <i>tripunc</i> <i>tatus</i> and <i>Crocot</i> <i>hemis</i> <i>servilia</i>					source of calcium for people with lactose intoleran ce and allergies to soy	
5 2	A. Barre et al.	2 0 1 4	Entomop hagy and the risk of allergy	Non specifi c	Non specifi c	Singu lar	Risk of allergy	y	-	Because of the existence of cross- reactive allergens in insects, it seems wise to advise

										individual s known to be allergic to shellfish or mollusks to avoid eating edible insects.
53	H. Enghoff et al.	2014	Millipede s as food for humans: their nutritiona l and possible antimalar ial value -	<i>Diplo oda</i>	Human	Non specif ic	Malabsorp tion risk	n	The milliped es' defensiv e secretio ns, hydroge n cyanide	Contents of unsaturate d fatty acids, calcium, and iron in millipede s are

			a first report						and benzoquinones, may act as insect-repellents.	particularly high
54	C. U. Igwe et al.	2014	Biochemical and haematologic effects of intake of macrotermes nigeriensis fortified functional diet	Macrotermes	Non specific	Prolonged	Hematologic and qualitative measurements at alternate	-		Fortified diets do not have detrimental hepatic, renal or haematologic effects but rather may be recommended for

							tion n ris k Gr ow th alt era tio n ris k			fortificati on of human and animal.
5 5	J. B. Jadall a et al.	2 0 1 4	Effects of inclusion of different levels of watermel on bug meal in	Water melon bug	Anima l (poultr y)	Prolo nged	Ma lab sor pti on ris k Gr	n	-	Watermel on bug meal could replace sorghum grains as source of

			broiler rations on feed intake, body weight changes and feed conversio n ratio in North Kordofan , Sudan				ow th alt era tio n ris k			energy in broiler rations
5 6	K. Koc et al	2 0 1 4	Biomonit oring of the genotoxic effects and oxidative potentials	<i>Onitis</i> <i>sp.</i> , <i>Caelife</i> <i>ra sp.</i> , and <i>Gryllot</i> <i>alpa</i> <i>sp.</i>	Human	Non specif ic	Chemical contamina tion risk	y	-	Studied insects can be consumed safely, but it is necessary to

			of commerci al edible dung beetles (Onitis sp.), grasshop per (Caelifera sp.) and mole crickets (Gryllotal pa sp.) in vitro							consider the cellular damages which are likely to appear dependin g on oxidative stress at higher concentra tions.
5 7	R. Musu ndire et al.	2 0 1 4	Nutrient and anti- nutrient compositi on of	<i>Henicu s whella ni</i>	Non specifi c	Non specif ic	Ch em ica l co	y	-	The relatively high ash content compared

			Henicus whellani (Orthoptera: Stenopelmatidae), an edible ground cricket, in south- eastern Zimbabwe				nta mi nat ion ris k Ma lab sor pti on ris k			with that from other edible insects indicates a rich source of minerals such as calcium, iron, magnesium, phosphorus and potassium . However, the presence of
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										saponins, oxalates and tannins could be a limitation.
58	H. Turkez et al.	2014	The cytogenetic effects of the aqueous extracts of migratory locust (<i>Locusta migratoria</i> L.) in vitro	<i>Locusta migratoria</i>	Non specific	Non specific	Chemical contamination risk	n	-	Extracts of <i>Locusta migratoria</i> did not exhibit genotoxicity at tested concentrations
5	K. C.	2	House	Yellow	Human	Singu	Risk of	y	-	Based on

9	M. Verhoeckx et al.	014	dust mite (Der p 10) and crustacea n allergic patients may react to food containin g Yellow mealwor m proteins	mealw orm		lar	allergy			these cross-reactivity studies, there is a realistic possibilit y that HDM- and crustacea n allergic patients may react to food containin g Yellow mealwor m proteins.
6	B.	2	Oryctes	<i>Orycte</i>	Non	Non	Malabsorp	n	-	The larva

0	Assie lou et al.	0 1 5	owariensi s larvae as good alternativ e protein source: nutritiona l and functiona l properties	s owarie nsis	specifi c	specif ic	tion risk			flour shows good functional characteri stics for use in many food industries .
6 1	H. Bare nnes et al.	2 0 1 5	Insect Consump tion to Address Undernut rition, a National Survey on the Prevalenc	Eggs of weaver ants, short- tailed cricket s, cricket s,	Human	Singu lar	Risk of allergy	y	-	Entomop hagy is general in Laos, and well accepted despite a decreasin g trend in consumpt

			e of Insect Consump tion among Adults and Vendors in Laos	grassh oppers, and cicadas						ion
6 2	M. Baus erma n et al.	2 0 1 5	A cluster- randomiz ed trial determini ng the efficacy of caterpilla r cereal as a locally available	Caterpi llars	Human	Prolo nged	Ma lab sor pti on ris k Gr ow th alt era	n	-	Infants who consumed caterpillar cereal had higher Hb concentra tion and fewer were anaemic, suggestin

			and sustainabl e complem entary food to prevent stunting and anaemia				tio n ris k He ma tic an d qu alit ati ve me at alt era tio n ris k			g that caterpillar cereal might have some beneficial effect.
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							Ma			TML did
							lab			not affect
							sor			feed
							pti			intake
							on			and
			Yellow				ris			growth
			mealwor				k			rate of
			m larvae				Gr			broilers.
			(Tenebrio				ow			The
			molitor,				th			lowest
6	F.	2	L.) as a	<i>Tenebr</i>	Anima		alt	n n		albumin-
3	Bove	0	possible	<i>io</i>	l	Prolo	era	y	-	to-
	ra et	1	alternativ	<i>molitor</i>	(poultr	nged	tio			globulin
	al.	5	e to	<i>larvae</i>	y)		n			ratio in
			soybean				ris			broilers
			meal in				k			fed on
			broiler				He			TML
			diets				ma			suggests a
							tic			higher
							an			immune
							d			response,
							qu			probably

							alit ati ve me at alt era tio n ris k			due to the prebiotic effects of chitin.
6 4	H. Broe kman et al.	2 0 1 5	Effect of thermal processin g on mealwor m allergenic ity	Mealw orm	Human	Singu lar	Risk of allergy	y	-	Thermal processin g did not lower allergenic ity but clearly changed solubility of

										mealworm allergens.
65	X. Cheseto et al.	2015	Potential of the desert locust <i>Schistocerca gregaria</i> (Orthoptera: Acrididae) as an unconventional source of dietary and therapeutic sterols	<i>Orthoptera: Acrididae</i>	Human	Non specific	-	Desert locust ingests phytosterols from a vegetative diet and, amplifies and metabolizes them into derivatives with potential salutary	-	

									benefits	
666	L. Hernandez - Flores et al.	2015	Bacteria Present in Comadia redtenbacheri Larvae (Lepidoptera: Cossidae)	<i>larvae of Comadia redtenbacheri Hammerschmidt</i>	Non specific	Non specific	Microbiological contamination risk	y -		This indicates that bacterial flora can vary in accordance with how the larvae are handled during extraction, collection, and transport.
67	H. Ji et al.	2011	Effect of replacement of	Silkworm pupae	Animal (fish)	Prolonged	Growth	n y -		The study demonstrates that it

		5	dietary				alt			is
			fish meal				era			practical
			with				tio			to replace
			silkworm				n			50% of
			pupae				ris			the Jian
			meal on				k			carp
			growth				He			dietary
			performa				ma			FM
			nce, body				tic			protein
			compositi				an			with SP,
			on,				d			higher SP
			intestinal				qu			levels are
			protease				alit			not
			activity				ati			recomme
			and				ve			nded and
			health				me			that
			status in				at			oxidation
			juvenile				alt			status of
			Jian carp				era			the SP
			(Cyprinus				tio			should be
			carpio				n			carefully
							ris			

			var. Jian)				k			assessed.
68	O.T. Omotoso	2015	Nutrient composition, mineral analysis and anti-nutrient factors of Oryctes rhinoceros L. (Scarabaeidae: Coleoptera) and winged termites, Marcrotermes nigeriensis	Scarabaeidae: Coleoptera Termitidae: Isoptera	Non specific	Non specific	Chemical contamination monitoring risk	n		The levels at which antinutrient/secondary metabolites occur is not a threat to animals that feed on these two insects.

			s Sjostedt. (Termitid ae: Isoptera)							
6 9	C. Srinr och et al.	2 0 1 5	Identifica tion of novel allergen in edible insect, Gryllus bimaculat us and its cross- reactivity with Macrobra chium spp. allergens	Gryllus bimacu latus	Human	Singu lar	Ris k of all erg y	y	-	The allergens in Macrobra chium lanchester i were identified as AK and HC. In addition, hexameri n1B (HEX1B) was

										identified as a novel and specific allergen in G. bimaculat us.
7 0	J. J. Tang et al	2 0 1 5	Constitue nts from the edible Chinese black ants (Polyrhac his dives) showing protective effect on rat mesangia	<i>Polyrh achis dives</i>	Non specifi c	Non specif ic	-	-	The results of biologic al studies show that the Chinese black ants contain compou	-

			l cells and anti- inflamma tory activity						nds that display anti- inflamm atory, immuno suppress ie, and renoprot ective activitie s.	
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*Main risk analyzed:

Risk of allergy: reported allergic reaction or laboratory confirmation of known allergens.

Microbiological risk: reported microbiological contamination in any fase of production (collection, storage, transportation) or specific insect microbiological contamination.

Chemical risk: reported presence of insect contamination with any known risky chemical substance or with anti-nutrient factors

Malabsorption risk: reported risk of pathological nutrient malabsorption associated with the consumption of edible insects

Growth alteration risk: reported risk of pathological growth alteration associated with the consumption of edible insects.

Hematic and qualitative meat alteration risk: reported risk of pathological hematic and qualitative meat alteration associated with the consumption of edible insects.

Pharmacological effects: any reported pharmacological effects associated with the consumption of edible insects.

Flow-chart

